I may further add that the formula for band spectrum,

$$n' = \omega' + a'm'^2 + b'm'^3 + c'm'^4 + d'm'^5 + \dots$$

which I have deduced as an extension of Deslandre's formula, is one of the empirical formulæ used by Kayser and Runge for cyanogen bands (*Abhandl. d. Berlin. Akad. d. Wissensch.*, 1889, formula I_a). From $m' = 0$ to $m' = 150$, the difference in wave-lengths between calculation and observation seldom exceeds $\pm 0 \cdot 03 \times 10^{-10}$ m., which is quite within errors of observation. H. Nagaoka.

Physical Laboratory, Tokyo University, April 20.

Electromotive Force between Two Phases of the same Metal.

I was much interested in the letter of Mr. George Beilby in your issue of May 12. It may interest Mr. Beilby to know that I contributed a paper to the Institution of Civil Engineers on "The Effect of Stress on the Corrosion of Metals" (*Proc.* Inst. C.E., vol. cxviii., session 1893–4). On perusing this paper it will be seen that the results were somewhat analogous to the line of investigation Mr. Beilby is undertaking. The experiments were on an extensive scale, and were made on numerous samples of iron and steel. In each case a polished bar of the steel or other metal, of known chemical composition and physical properties, used was cut in two; one half was stressed, and the other remained in its normal state. Each pair of bars was immersed in sea water, as an electrolyte, forming the elements of a galvanic couple, with a delicate calibrated galvanometer in circuit, when a decidedly measurable E.M.F. was observed. It was invariably noticed that the alteration in the physical properties of the metals produced by the stress only in each stressed bar was sufficient to place that bar in the position of copper in a zinc copper cell, the normal unstressed bar answering to the zinc element in a galvanic couple.

A current is also set up between two polished bars of the same metal immersed in a suitable electrolyte, one being in its normal state and the other having had its microcrystalline structure altered by annealing, in the manner illustrated in a recent paper to the Institution of Civil Engineers ("Effects of Annealing on Steel Rails," by Thomas Andrews and Charles Reginald Andrews, *Proc.* Inst. C.E., vol. clvi., session 1903–4, part ii.). When a metal is stressed a similar effect is produced. I have for some time past been working on a research on the E.M.F. between normal and annealed metals, using in one part of the investigation a complete series of specially prepared pure iron and steel bars of varied and known chemical composition, the object of the investigation being to show the E.M.F. produced between annealed and unannealed metals. I am much pleased to learn that Mr. Beilby is also working on this very interesting subject.

Mr. Beilby may also be interested in a research which I made some years ago showing the E.M.F. produced between polished bars of platinum or other metals, cut from the same bar, the E.M.F. being attributable to difference of molecular structure induced by heating one of the bars. The electrolytes employed for these experiments were fused salts at a high temperature (see "Electrochemical Reactions between Metals in Fused Salts," by Thomas Andrews, *Trans.* Royal Society, Edinburgh, session 1885–6). I venture to suggest that the following papers ("Observations on Variations of the Electromotive Force between Metals at High Temperatures in Fused Salts," *Trans.* Royal Society, London, 1885; "Electrochemical Effects on Magnetising Iron," parts i., ii., iii., iv., *Trans.* Royal Society, London, 1887, 1888, 1889, 1892), which I published some time ago, may perhaps be helpful to Mr. Beilby in the course of his researches, the results of which I am looking forward to with much interest and pleasure. Thos. Andrews.

Wortley, near Sheffield, June 3.

Graphic Methods in an Educational Course in Mechanics.

In company, I think, with other correspondents, I have misunderstood Mr. Larden's use of the words "analytical methods." He alluded, it is true, to resolution and taking moments, but "analytical methods," especially when used in contradistinction to "graphical," have a much wider and more commonly received meaning. Dr. Murray's dictionary defines modern mathematical analysis as "the resolving of problems by reducing them to equations," and cites Hutton, "Course Math.," 1827, "Analysis or Analytical method is that which is commonly used in Algebra." Prof. Croom Robertson, in "Analysis" in the "Ency. Brit.," says:—"In modern times analysis has come to mean the employment of the algebraical and higher calculus, and synthesis any direct treatment of the properties of geometrical figures, in the manner of the ancients without the use of algebraical notation or transformations." "Analytical" is a hard-worked word, like potential and polarisation, and no doubt it may be used in Mr. Larden's sense. The word "analytical," in the sense of the employment of algebra and the higher calculus, is not self-explanatory, and "graphical" or "geometrical" are better for this reason than "synthetical," unless the philosophical aspect is under discussion.

There can be no question that for almost all mathematical calculation and research, algebraical methods are far more powerful than geometrical (but I make reservations), and teachers are perhaps for this reason apt to think that they are more useful and better suited for educational explanations of phenomena or of natural laws. If in mistaking Mr. Larden for an unusually pronounced teacher of this type I have protested too strongly, I apologise, but his parenthetical queries which I have provoked I deny.

That some persons have accurate musical "ears," and others "no ear for music," that some can draw excellently without having been taught, and others can never learn, may perhaps be explained by physiological psychology. Some are "good at languages," and others bad; some have a "good head for figures," and others not. Experts in pedagogy might be able to tell us whether this is due to some selective ability or inability. But that some persons use algebra and the calculus with facility, and are bored by geometry, while others have "no head for algebra," but have an aptitude for geometrical methods, seems to be a matter worthy of investigation by the mental philosopher.

Not only has Mr. Larden used "analytical" in a somewhat restricted sense, but in this discussion he limits "graphic methods" to "those methods that depend on accurate drawing only, there being no calculation. . . ." I will give one example of what I mean by a graphical method in an educational course. The fundamental idea of a differential coefficient is explained in the old text-books purely by symbols. Persons with "no head for algebra" find the greatest difficulty in grasping the idea. But draw a curve of speeds on the black-board, and explain that a tangent to it, or the slope at any point, gives the acceleration or rate of increase. You need no accurate drawing, no calculation, no algebra, but you give a perfectly clear idea of a differential coefficient.

It is rather hard that those who are called calculus dodgers cannot discuss the relative advantages of algebraical and geometrical methods without being accused of writing against mathematics or deprecatingly of mathematicians.

Westminster, June 6. A. P. Trotter.

Association of Economic Biologists.

For some time past workers engaged upon various problems connected with economic biology have felt the need of some organisation whereby they could meet from time to time to discuss these different problems with fellow-workers so as to bring out suggestions and to prevent unnecessary duplication of work, and generally to promote and advance the economic side of biological science.

With a view to the formation of such an association of economic biologists, I have briefly discussed the matter with a few fellow-workers, and I shall be pleased to receive an expression of opinion or suggestions from any others.

The idea at present in my mind is an association somewhat on the lines of the American one, which would include and welcome all investigators and teachers in economic biology in its widest sense.

Mr. Fred. V. Theobald (Wye) writes:—"Your suggestion for an Association of Economic Biologists is most excellent.

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. . . I will certainly do all I can to promote any such idea."

Mr. Robert Newstead (Chester) writes:—"You would have my heartiest support in the matter, as I feel that such an institution would be of material benefit to the Agriculturists and Horticulturists of this country."

Mr. A. E. Shipley (Cambridge) writes:—"I should welcome the founding of an Association of Economic Biologists if you think we are really strong enough. . . . If the Association is formed I hope it will be a really working one."

Mr. Cecil Warburton (Cambridge) writes:—"I heartily approve of your suggestion with regard to the formation of an Association of Economic Biologists in this country."

Similar letters or expressions of opinion have been received from Dr. A. H. R. Buller, Mr. Herbert Stone, and others. WALTER E. COLLINGE.

The University, Birmingham, May 30.

THE RELATION OF HUMAN TO BOVINE TUBERCULOSIS.

THE Royal Commission appointed to inquire into the relation of human and animal tuberculosis has presented an interim report published on June 1. The Commission was appointed in August, 1901, soon after Prof. Koch's address had been delivered at the British Congress on Tuberculosis held in London in July, 1901, in which he stated that as the result of experiments on animals, cattle, pigs, asses, sheep, and goats, he "felt justified in maintaining that human tuberculosis differs from bovine tuberculosis, and cannot be transmitted to cattle," and he also stated that "though the important question whether man is susceptible to bovine tuberculosis at all is not yet absolutely decided, and will not admit of absolute decision to-day or to-morrow, one is, nevertheless, at liberty to say that, if such a susceptibility really exists, the infection of human beings is but of very rare occurrence. I should estimate the extent of the infection by the milk and flesh of tuberculous cattle and the butter made of their milk as hardly greater than that of hereditary transmission, and I, therefore, do not deem it advisable to take any measures against it." According to Koch the chief danger of infection is from human tuberculous sputum. He suggested as the most important means of combating the disease the improvement of general hygienic conditions, provision of suitable hospitals and sanatoria for consumptives, and inspection and disinfection.

Lord Lister, at the conclusion of Prof. Koch's address, struck a note of warning. He pointed out "how serious and grievous a thing it would be if the rules now in force for securing purity of milk supply should be relaxed, and it should turn out after all that the conclusion was erroneous." This attitude was taken up by a number of other leading pathologists. Since Koch's statement a number of workers have published the results of experiments on the subject, and the bulk of the evidence has been opposed to Koch's view.

The most striking and interesting pronouncement on the subject has been from one of Koch's most distinguished pupils, von Behring, who on this subject places himself in a position entirely opposed to that of his old master. To many minds von Behring's view appears to be as extreme as Koch's. He holds that "the main source to which phthisis must be traced is the milk diet of infants." He found that in young animals such as guinea pigs, owing to the incomplete continuity of the epithelium, numerous bacilli, and among them the tubercle bacillus, could pass through the wall of the alimentary canal, giving rise to a tuberculosis of the cervical glands of the type of scrofula in the human subject, and that at a later period these animals not infrequently developed a type of tuberculosis which has been regarded as indicative of inhalation tuberculosis. The freedom with which milk-bacilli find their way through the walls of the alimentary tract into the circulation owing to the incomplete continuity of the epithelium and absence of active ferment secretion in young animals makes "the disposition to tuberculous infection entirely physiological and normal."[1] At a later period in life a similar susceptible state may be induced by the exanthemata such as scarlet fever and measles. Von Behring, along with Römer, has also shown that immunity may be conferred on bovines by injection of tubercle bacilli of human origin, a striking argument in favour of the specific relationship of the two types of bacilli. These views, which have appeared since the appointment of the Commission, have only emphasised the need of further investigation.

The commissioners state that they felt it their duty to publish this interim report because the experimental results obtained by them are so striking.

The Commission was to inquire and report with respect to tuberculosis:—

(1) Whether the disease in animals and man is one and the same.

(2) Whether animals and man can be reciprocally infected with it.

(3) Under what conditions, if at all, the transmission of the disease from animals to man takes place, and what are the circumstances, favourable or unfavourable, to such transmission.

The first line of inquiry upon which the Commission entered was to ascertain the effects produced by introducing into the body of the bovine animal, either through the alimentary canal as food or directly into the tissues by subcutaneous or other injection, tuberculous material of human origin, that is, material containing living tubercle bacilli obtained from various cases of tuberculous disease in human beings, and how far these effects resembled or differed from the effects produced by introducing into the bovine animal under conditions as similar as possible tuberculous material of bovine origin, that is, material containing living tubercle bacilli obtained from cases of tuberculous disease in the cow, calf, or ox. More than twenty strains of tubercle bacilli have been employed, that is to say, the material taken from more than twenty cases of tuberculous disease in human beings. The effects produced were compared with those resulting from the injection of different strains of tuberculous material of bovine origin. In the case of seven of the above strains of human origin the injection of the human tuberculous material into cattle gave rise at once to acute tuberculosis, with the development of widespread disease in various organs of the body. In some instances the disease was of remarkable severity. In the case of the remaining strains the effects were less marked. The tuberculous disease was either limited to the spot where the material was introduced (this occurred, however, in two instances only, and these at the very beginning of their inquiry), or spread to a variable extent from the site of inoculation along the lymphatic glands with, at most, the appearance of a very small amount of tubercle in such organs as the lungs and spleen. Material, however, taken from the bovine animal thus affected and introduced into other bovine animals has, up to the present, in the case of at least five of these remaining strains, ultimately given rise in the bovine animal to general tuberculosis of an intense character. The disease thus set up in the bovine animal by material of human origin has been compared with that set up

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